

BUILDING TECHNOLOGIES PROGRAM**2009 and 2012 IECC; ASHRAE 90.1-2007
and 2010; 2009 and 2012 IMC**

Duct Insulation and Sealing Requirements in Commercial Buildings

Duct insulation and sealing, especially insulated supply ducts delivering conditioned air within a building, save energy. The intent of energy efficiency codes, as related to duct insulation and sealing, is to keep mechanically warmed or cooled air as close to a constant, desired temperature as possible and prevent the conditioned air from escaping the duct system while it is being moved to spaces where it is needed. If reduced heat transfer through insulated ducts is accounted for in the heating, ventilating, and air conditioning (HVAC) load calculations, it may even be possible to reduce the size of HVAC equipment.

Locations in which duct/plenum insulation is required are identified below (see “Code Citations” described later in this code note for additional detail):

- Supply and return ducts/plenums in unconditioned spaces
- Supply and return ducts or plenums located outside the building
- Supply and return ducts or plenums located within exterior components (floors, walls, or roofs) where the duct or plenum touches the exterior component.

Locations on the duct system that should be sealed are identified below (see “Code Citations” described later in this code note for additional detail):

- All transverse joints, longitudinal seams, and duct wall penetrations
- Air handlers
- Filter boxes.

Plan Review

1. Verify where the code requires ducts to be insulated; such requirements are called out on the mechanical plans/schedule or in the project specifications.
2. Verify that the duct insulation R-values are called out on the mechanical plans/schedule.
3. Verify that the duct pressure class is designated in design documents (drawings or specifications).
4. Verify that sealing is required in design documents and that, if tape is allowed, it complies with the requirements of ASHRAE 90.1, Section 6.4.4.2.1, or the International Mechanical Code, Section 603.9, as applicable.
5. Verify all joints and penetrations are required to be sealed as stated in the code.



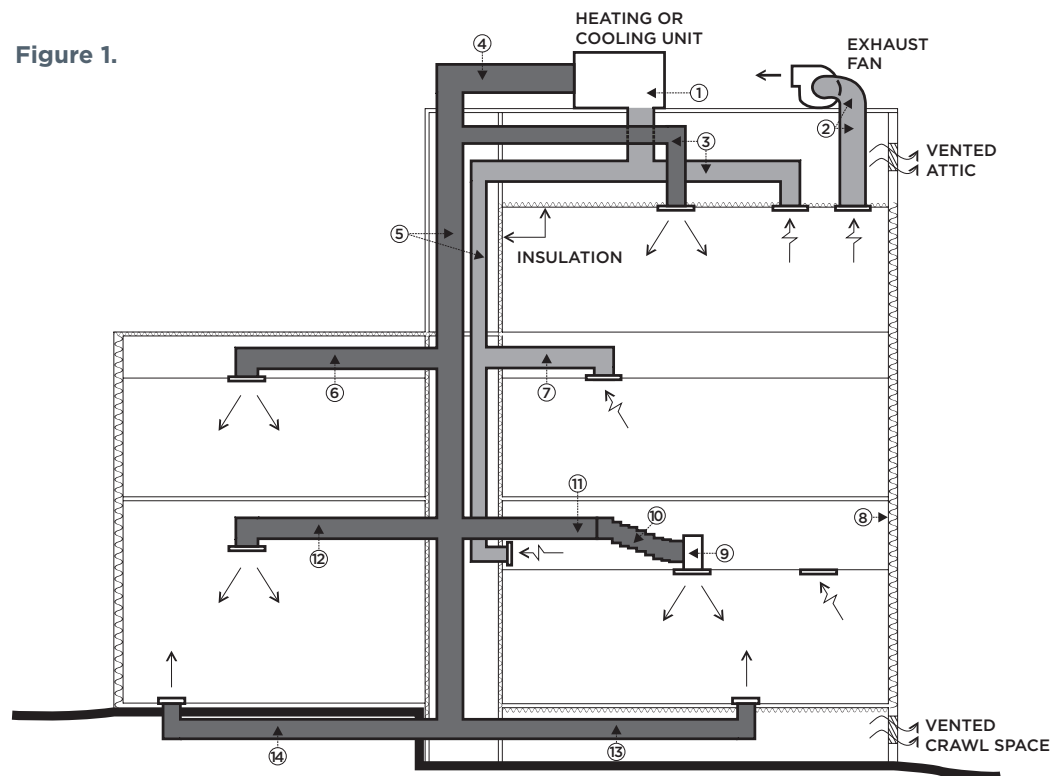
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Duct Insulation and Sealing Requirements in Commercial Buildings *(Continued)*

Inspection

1. Verify that supply and return ducts and plenums have been insulated to the specified R-value in accordance with the approved mechanical plans/schedule.
2. Verify that ducts have been sealed in accordance with approved design documents and code requirements. Verifying all seams and connections for the entire duct system in a commercial building can be tedious and time consuming. Typically, inspectors will perform spot checks to confirm the seams and connections are being sealed properly. Testing the duct system for air tightness provides the final confirmation of proper duct sealing.
3. Verify that ducts and plenums operating at static pressures exceeding 3-in. water gauge (w.g.) have been leak tested in accordance with IECC 2009/2012, Section 503.2.7.1.3/ C403.2.7.1.3 or ASHRAE 90.1-2007/2010 Section 6.4.4.2.2.
4. Verify that ducts have been sealed in accordance with approved design documents and code requirements.

Figure 1.



KEY

- | | |
|---|------------------------------------|
| 1. INSULATION OF UNIT CASING | 8. EXTERIOR WALL OF RETURN PLENUM |
| 2. EXHAUST | 9. SUPPLY OUTLET IN PLENUM |
| 3. SUPPLY & RETURN IN VENTED ATTIC | 10. SUPPLY RUNOUT IN RETURN PLENUM |
| 4. SUPPLY & RETURN OUTSIDE OF BUILDING | 11. SUPPLY IN RETURN PLENUM |
| 5. SUPPLY & RETURN IN UNCONDITIONED SHAFT | 12. SUPPLY IN CONDITIONED SPACE |
| 6. SUPPLY IN UNVENTED ATTIC | 13. SUPPLY IN VENTED CRAWL SPACE |
| 7. RETURN IN INDIRECTLY CONDITIONED CEILING SPACE | 14. BURIED SUPPLY |



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Duct insulating requirements for components shown in Figure 1:

1. No insulation requirement.
Factory-installed ductwork within unit casings is exempt from insulation requirements.
2. No insulation requirement. Insulation requirements are specified only for supply and return ductwork, not for exhaust ducts.
3. Insulation R-value requirements for unconditioned spaces in the IECC or for a vented attic in ASHRAE 90.1 must be met.
4. Insulation R-value requirements for exterior or outdoor locations must be met.
5. Insulation R-value requirements for unconditioned spaces in the IECC or for unconditioned spaces in ASHRAE 90.1 must be met.
6. Insulation R-value requirement for unconditioned spaces in the IECC or for unvented attics in ASHRAE 90.1 must be met.
7. No insulation requirement. ASHRAE 90.1 has no insulating requirements for indirectly conditioned spaces. In the IECC, such spaces would be considered conditioned spaces, also with no duct insulation requirement.
8. Insulation R-value must meet either the requirement for above-grade walls or for exterior ducts. If the lesser R-value (most likely the duct R-value) is chosen, the envelope of the building must be shown to comply with a performance-based option.
9. Insulation R-value to match the supply duct.
10. No insulation requirement beyond what is integral to flexible duct, unless the length of flex duct exceeds 10 ft.
11. No insulation requirement in the IECC. If following ASHRAE 90.1, ducts must meet the requirements for indirectly conditioned space.
12. No insulation requirement in IECC. These ducts are located in conditioned space. Insulation may be installed for sound-reduction purposes or to control condensate, but it is not required.
13. Insulation R-value requirements for unconditioned spaces in the IECC or for an unvented attic in ASHRAE 90.1 must be met.
14. Insulation R-value requirements for locations outside the building must be met if adhering to IECC. If ASHRAE is being followed, these ducts must be insulated to the level required for buried ducts.



Code Citations*

IECC 2009, Section 503.2.7, Duct and Plenum Insulation and Sealing [IECC 2012, Section C403.2.7]

All supply and return air ducts and plenums shall be insulated with a minimum of R-5 [R-6] insulation when located in unconditioned spaces and a minimum of R-8 insulation when located outside the building. When located within



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a building assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-8 insulation.

Exceptions:

1. When located within equipment
2. When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C).

All ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the International Mechanical Code.

2009 IECC, Section 503.2.7.1.3, High-Pressure Duct Systems

[2012 IECC, Section C403.2.7.1.3]

Ducts designed to operate at static pressures in excess of 3 inches water gauge (w.g.) (746 Pa) [(750 Pa)] shall be insulated and sealed in accordance with Section 503.2.7 [Section C403.2.7]. In addition, ducts and plenums shall be leak-tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual*¹ with the rate of air leakage (CL) less than or equal to 6.0 as determined in accordance with Equation 5-2 [Equation 4-5].

$$CL = F/P^{0.65} \quad \text{Equation 5-2}^2 \text{ [Equation 4-5]}$$

where:

- F = The measured leakage rate in cfm per 100 square feet of duct surface.
 P = The static pressure of the test.

Documentation shall be furnished by the designer demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.

ASHRAE 90.1-2007/2010, Section 6.4.4.1.2, Duct and Plenum Insulation

All supply and return ducts and plenums installed as part of an HVAC air distribution system shall be thermally insulated in accordance with Tables 6.8.2A and 6.8.2B.

Exceptions:

- a. Factory-installed plenums, casings, or ductwork furnished as a part of HVAC equipment tested and rated in accordance with Section 6.4.1, Equipment Efficiencies, Verification, and Labeling Requirements.
- b. Ducts or plenums located in heated spaces, semiheated spaces, or cooled spaces.
- c. For runouts less than 10 ft in length to air terminals or air outlets, the rated R-value of insulation need not exceed R-3.5.
- d. Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas exceeding 5 ft² need not exceed R-2; those 5 ft² or smaller need not be insulated.

ASHRAE 90.1-2007, Section 6.4.4.2.1, Duct Sealing

Ductwork and plenums shall be sealed in accordance with Table 6.4.4.2A (Table 6.4.4.2B provides definition of seal levels), as required to meet the requirements of Section 6.4.4.2.2 (Duct Leakage Tests) and with standard industry practice (see Informative Appendix E).

¹ The SMACNA HVAC Air Duct Leakage Test Manual can be ordered from SMACNA at www.smacna.org/bookstore.

² There was a typo in the 2009 IECC that showed Equation 5-2 as $CL = F \times P^{0.65}$, the error is corrected here for clarity.



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Duct Insulation and Sealing Requirements in Commercial Buildings *(Continued)*

Table 6.8.2A. Minimum Duct Insulation R-Value,^a Cooling and Heating Only Supply Ducts and Return Ducts

Duct Location							
Climate Zone	Exterior	Ventilated Attic	Unvented Attic above Insulated Ceiling	Unvented Attic with Roof Insulation ^a	Unconditioned Space ^b	Indirectly Conditioned Space ^c	Buried
Heating-Only Ducts							
1, 2	none	none	none	none	none	none	none
3	R-3.5	none	none	none	none	none	none
4	R-3.5	none	none	none	none	none	none
5	R-6	R-3.5	none	none	none	none	R-3.5
6	R-6	R-6	R-3.5	none	none	none	R-3.5
7	R-8	R-6	R-6	none	R-3.5	none	R-3.5
8	R-8	R-8	R-6	none	R-6	none	R-6
Cooling-Only Ducts							
1	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
2	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
3	R-6	R-6	R-6	R-3.5	R-1.9	none	none
4	R-3.5	R-3.5	R-6	R-1.9	R-1.9	none	none
5, 6	R-3.5	R-1.9	R-3.5	R-1.9	R-1.9	none	none
7, 8	R-1.9	R-1.9	R-1.9	R-1.9	R-1.9	none	none
Return Ducts							
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none
<p>a Insulation R-values, measured in (h-ft²·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of Section 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.</p> <p>b Includes crawlspaces, both ventilated and nonventilated.</p> <p>c Includes return air plenums with or without exposed roofs above.</p>							



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Duct Insulation and Sealing Requirements in Commercial Buildings *(Continued)*

Table 6.8.2B. Minimum Duct Insulation R-Value,^a Combined Heating and Cooling Supply Ducts and Return Ducts

Duct Location							
Climate Zone	Exterior	Ventilated Attic	Unvented Attic above Insulated Ceiling	Unvented Attic with Roof Insulation ^a	Unconditioned Space ^b	Indirectly Conditioned Space ^c	Buried
Supply Ducts							
1	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
2	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
3	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
4	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
5	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
6	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
7	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
8	R-8	R-8	R-8	R-1.9	R-6	none	R-6
Return Ducts							
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none
<p>a Insulation R-values, measured in (h-ft²·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of Section 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.</p> <p>b Includes crawlspaces, both ventilated and nonventilated.</p> <p>c Includes return air plenums with or without exposed roofs above.</p>							

Table 6.4.4.2A. Minimum Duct Seal Levels^a

Duct Type				
Duct Location	Supply		Exhaust	Return
	≤2-in. w.c. ^b	>2-in. w.c. ^b		
Outdoor	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces ^c	C	B	B	C
<p>a See Table 6.4.4.2B description of seal level.</p> <p>b Duct design static pressure classification.</p> <p>c Includes indirectly conditioned spaces such as return air plenums.</p>				

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Duct Insulation and Sealing Requirements in Commercial Buildings *(Continued)*

Table 6.4.4.2B. Duct Seal Levels

Seal Level	Sealing Requirements ^a
A	All transverse joints, longitudinal seams, and duct wall penetrations. Pressure sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL-181A or UL0181B by an independent testing laboratory and the tape is used in accordance with that certification.
B	All transverse joints, longitudinal seams. Pressure sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL-181A or UL0181B by an independent testing laboratory and the tape is used in accordance with that certification.
C	Transverse joints only.
^a Longitudinal seams are joints oriented in the direction of flow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw fastener, pipe, rod, or wire. Spiral lock seams in a round or flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, taps, and other branch connections, access door frames and jambs, duct connections to equipment, etc.	

ASHRAE 90.1-2010, Section 6.4.4.2.1, Duct Sealing

Ductwork and all plenums with pressure class ratings shall be constructed to seal class A, as required to meet the requirements of Section 6.4.4.2.2 (Duct Leakage Tests), and with standard industry practice (see Informative Appendix E). Openings for rotating shafts shall be sealed with bushings or other devices that seal off air leakage. Pressure-sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification. All connections shall be sealed, including but not limited to spin-ins, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed. All duct pressure class ratings shall be designated in the design documents.

ASHRAE 90.1-2007/2010, Section 6.4.4.2.2, Duct Leakage Tests

Ductwork that is designed to operate at static pressures in excess of 3 in. w.c. and all ductwork located outdoors shall be leak-tested according to industry-accepted test procedures (see Informative Appendix E). Representative sections totaling no less than 25% of the total installed duct area for the designated pressure class shall be tested. All sections shall be selected by the building owner or the designated representative of the building owner. Positive pressure leakage testing is acceptable for negative pressure ductwork. The maximum permitted duct leakage shall be

$$L_{\max} = C_L P^{0.65}$$

where:

L_{\max} = maximum permitted leakage cfm/100 ft² duct surface area
 C_L = 4, duct leakage class, cfm/100 ft² duct surface area at 1-in. w.c.
 P = test pressure, which shall be equal to the design duct pressure class rating, in. w.c.



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Duct Insulation and Sealing Requirements in Commercial Buildings *(Continued)*

2009 IMC, Section 603.9, Joints, Seams, and Connections [2012 IMC, Section 603.9]

All longitudinal and transverse joints, seams and connections in metallic and nonmetallic ducts shall be constructed as specified in SMACNA HVAC *Duct Construction Standards—Metal and Flexible* and NAIMA *Fibrous Glass Duct Construction Standards*. All joints, longitudinal and transverse seams and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, liquid sealants or tapes. Closure systems used to seal ductwork listed and labeled in accordance with UL 181A shall be marked “181A-P” for pressure-sensitive tape, “181A-M” for mastic or “181A-H” for heat-sensitive tape. Closure systems used to seal flexible air ducts and flexible air

connectors shall comply with UL 181B and shall be marked “181B-FX” for pressure-sensitive tape or “118B-M” for mastic. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply with UL 181B and shall be marked “181B-C.” Closure systems used to seal metal ductwork shall be installed in accordance with the manufacturer’s installation instructions. Unlisted duct tape is not permitted as a sealant on any duct.

Exception:

Continuously welded and locking-type longitudinal joints and seams in ducts operating at static pressures less than 2 inches of water column (500 Pa) pressure classification shall not require additional closure systems.

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